auction. Finally, we explain that even if policymakers are skeptical of procurement auctions, one could be implemented quickly as part of an initial tranche of stimulus funding in order to test its efficacy relative to traditional approaches. This approach would allow NTIA/RUS to quickly expand upon or modify the procurement auction program in subsequent funding rounds.

II. Procurement Auctions are more Efficient than Traditional Grantmaking Approaches

A. Traditional Approaches for Distributing Grants are Cumbersome and Slow

Traditionally, subsidy programs require firms to submit lengthy applications and the government to pick the "best ones" after reviewing all the competing applications. This approach has at least three problems for the purpose of distributing the funds from the stimulus bill.

First, the traditional approach is inherently time-consuming. Firms must complete complex proposals that government officials must subsequently spend time reviewing. USDA's Rural Utility Service (RUS), whose awards include broadband support, noted in its 2007 Annual Report that in 2006 the average application took six months to process (and this was an improvement from previous years when the average processing time was nearly a year).[5] That estimate does not include time firms spent preparing those applications. Complex broadband grants have taken far longer—several years in some instances.[6] Such delays are inconsistent with the goals of speedy stimulus grants.

Second, the qualitative nature of the applications makes it difficult to compare one project to another. For example, it will be difficult to choose between, say, a fiber project in Texas and a wireless project in North Dakota. Reviewing and deciding between large numbers of grant applications will inevitably lead to inconsistent and seemingly arbitrary decisions. And, the unpredictability of decisions will make it harder for companies to determine and propose the most appropriate projects.

Third, it is difficult to design a grant application system to ensure that firms receive only the minimum subsidy necessary to achieve a goal. To determine the "correct" subsidy level the government could attempt to calculate the necessary subsidy using available information, but this effort would be time-intensive, costly, and inaccurate. Alternatively, it could rely on the applicant's own estimate, but applicants have little incentive to ask for the bare minimum required. Either approach will result in a suboptimal allocation of subsidy dollars.

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[5] USDA Rural Utility Service. 2007. *USDA Rural Development: Bringing Broadband to Rural America.* http://www.rurdev.usda.gov/rd/pubs/RDBroadbandRpt.pdf

[6] Open Range Communications disclosed that it had spent over three years and submitted over 30,000 pages of application materials before its RDUP loan was granted. See http://www.businesswire.com/news/google/20071022006575/en

Reviewing grant applications is not an appropriate way to distribute broadband stimulus grants. NTIA/RUS requires a more objective and efficient methodology. Competitive bidding by procurement auction is the best approach.

B. Procurement Auctions Can Allocate Funds Flexibly, Efficiently and Fairly

An objective, "mechanistic" approach that applies specific, quantitative criteria can be both easier to implement and lead to more efficient outcomes than traditional grant application review. Procurement auctions, in particular, can lead to more efficient grant disbursal than traditional qualitative approaches.[7]

An auction is a mechanism for making smart allocation choices when confronted with overwhelming amounts of information and no relevant market exists. In a typical auction for a good, bids increase until the auction identifies the entity willing to pay the most for the good being auctioned. In the simplest procurement or "reverse" auction, bids consist of how much an entity must be paid to provide a good or service. The procurement auction thus identifies the entity willing to provide the good or service for the smallest amount of money.

Though it may sound exotic, a procurement auction is just a competitive bidding process and analogous to any government procurement. When the government needs to purchase something, it describes specifically what it wants, firms submit bids to provide the service, and the government picks the firm that submits the best bid.[8] The best bid may be the lowest, but the government may also take other factors into account when making the decision, especially in the case of complex projects.[9]

In procurement auctions for broadband, the government would specify its objective and ask firms to bid for the right to meet that objective. Consider, for example, a rural area with no broadband service. The government can ask firms to bid for a subsidy that would make it profitable for the firm to provide service. Firms and other organizations would compete against each other by bidding down the subsidy they need to offer service. The firm that commits to provide broadband in that area for the smallest subsidy would win the grant.

Procurement auctions have several advantages over traditional methods of distributing grants. First, once the auction rules are in place they relieve the government of the task of

[7] The Federal Communications Commission (FCC) and Congress realized more than a decade ago that the traditional proposal-review approach was inefficient. Historically the FCC had granted spectrum licenses based on comparative hearings. These hearings could not be done quickly and put the FCC in the impossible position of processing tractor trailer-loads of paperwork to decide which companies were best suited to providing services in a given spectrum band. In 1994, the FCC began to allocate spectrum via auctions, which could occur quickly and allocate spectrum far more efficiently than could any administrative comparative process. This model has been used successfully in the U.S. and around the world ever since.

[8] See some federal procurement guidelines here: http://www.whitehouse.gov/omb/procurement/index_guides.html

[9] While it is easier to conduct this process for simple products, the government also uses it to supply highly complex goods like weapons systems See, for example, http://www.nytimes.com/2008/03/10/business/worldbusiness/10tanker.html?fta=y and www.gao.gov/cgi-bin/getrpt?GAO-06-364.

identifying the "best" projects – the government sets forth its objectives in advance of the auction. This also enables and encourages bidders to tailor their projects to the government's actual criteria. Second, because auctions use competition among providers to determine the subsidy required to achieve any particular goal, the government does not have to estimate the subsidy actually required for any given project. Reducing the subsidy for any given project frees up money that can be used for additional projects. Finally, they inherently induce firms to contribute their own investment to increase the chance that their bid is accepted.[10]

C. Clear Selection Criteria are Critical for any Selection Program

Crucial to the success of any plan, not just procurement auctions, is having clear objectives. In the case of the broadband stimulus the objectives include creating new jobs and improving broadband. It is not possible to maximize both objectives simultaneously. From the language of the Act and public discussions about it thus far we can assume that the most important objective is to maximize new broadband availability subject to creating some minimum level of new economic activity.

In general, stimulus funds would be awarded to those bidders that maximize broadband expansion with the lowest subsidy amount. Through the auction process bidders would be able to "bid down" the subsidy as they compete with other bidders seeking the same stimulus dollars.

Careful auction design is crucial to ensuring an efficient outcome. It is important to keep in mind two general points. First, the criteria on which the bids will be scored or ranked must be clear. As a simple example, bids could consist of subsidy requested per household connected or per household to which broadband service is newly available.[11] Then bids could be ranked from smallest subsidy requested to the largest, and funds distributed according to that ranking.

Second, the ability to "game" the procurement process increases with the ambiguity of the rules and the number of criteria included in a bid. For example, an auction in which firms had to demonstrate that their bid was in the "public interest" and specify a subsidy per household, the number of new households served, the service speeds, reliability, latency, mobility, and price would probably not work well due to the ambiguity of what, exactly, "public interest" means and the large number of criteria on which firms bid.

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[10] Procurement auctions are sound and have been used successfully around the world to bring telecommunications services to areas that previously had none. Experiences in other countries, including Australia, India, Chile, Peru, and others demonstrate that procurement auctions can substantially bring down the subsidies required to induce buildout. Their experiences also teach us that it will be important to get the details right.

[11] It will be important not to confuse supply and demand for broadband. About half of all people without broadband say that they are not interested in it. Because the stimulus focuses primarily on supply, we may want to focus on newly available broadband as opposed to newly adopted.

Note that the need to identify unambiguous, simple criteria on which to judge bids in advance of the auction is actually an advantage, not a disadvantage, of procurement auctions. It may appear at first blush that traditional grant reviews do not face similar problems, but that is incorrect. If a grant review process does not undergo the same identification task then it will likely lead to arbitrary and inconsistent decisions.

In addition to those very general points, this auction must be designed in a way that does not arbitrarily benefit one technology over another. Organizations could, therefore, bid to upgrade copper services in order to make DSL feasible, upgrade or install coaxial cable to facilitate cable broadband, or upgrade or install wireless and satellite broadband equipment. With scoring rules set out in advance bidders could know how they would have to bid and consider competing technologies or providers in other geographic areas.

III. A Straw-Man Procurement Auction Plan for Allocating NTIA/RUS Broadband Subsidies

A. Auction Design

This section describes economic methodology and other considerations for devising an effective procurement auction program. The detailed rules of the auction will be crucial, as they will affect the outcome.[12] NTIA/RUS will have to make several decisions as it creates these rules. We list some of the issues below.

The first step is the same for both a procurement auction and a traditional grant review process: NTIA/RUS must identify and define unserved and underserved regions. Ideally, most of these regions would be specified to have similar numbers of unserved/underserved households, so that the service costs across regions can be easily compared, and to be just large enough that projects of that scale are meaningful to the bidders. NTIA/RUS could identify these areas using existing data or bidders could propose and certify unserved areas. Each eligible project would need to offer qualifying service to at least 95% of the unserved households in the region.[13]

Having defined either the regions or the mechanism for defining the regions, the rules for the procurement auction begin to diverge from the traditional grant review process. NTIA/RUS should set out a framework for scoring projects in terms of a standard unit of supply. This could be a simple metric, such as "newly served population" (defined as the population to which service above a minimum bandwidth threshold is newly available) or a more involved measure such as "effective bandwidth supplied" (defined as the population

[12] If there is enough time, it would be useful to design experiments to test auction rules. In section III, we suggest allocating the money in tranches to learn about the process and make changes based on those outcomes.

[13] The required percentage of homes in the area could be set at a different level, or it could be set by the bidders and scored as part of the auction evaluation.

to which service is newly available adjusted for the speed of service.[14]) Each bid would be characterized in terms of effective supply and cost. We advise against introducing additional dimensions to the evaluation. It is particularly problematic to introduce subjective criteria, which undermine the quick and objective comparisons required by an effective auction.

In a sealed-bid auction, the winning bids maximize the total effective supply, subject to the government's spending and other constraints.

Ideally, the government would include multiple regions with a limited budget in a single auction, in order to encourage competition among bidders offering diverse services in different areas. Particularly in large auctions, the government should allow bidders to specify a maximum number of projects that they might win from any non-overlapping sets of projects and a further maximum for collections of such sets of projects. By protecting bidders from the risk of winning too many projects in any set and overall, this feature encourages firms to submit additional proposals, increasing the level of competition.

Auctions are adaptable to respect a wide range of policy concerns. The government could use instruments similar to ones that have been employed in FCC auctions, such as limiting the number of projects won by any single bidder or offering bidding credits to small businesses. And, to spread the effects of the subsidy geographically, the government could give greater weight to the first households served in a state or region than to additional households.

We recommend that pay-as-bid pricing applies: winning bidders should provide the project and receive the subsidy described in their bids. This system is simple and pay-as-bid pricing is common in procurement auctions.

The variations we have described relate to characteristics of the bidder or the region being served. It is easy in principle to add other sorts of factors to the bidding menu. However, the more dimensions on which firms bid, the more likely it becomes that there are easy ways for firms to game the system. We recommend limiting the factors to price and effective supply, especially in the first implementation to test the auction system. With a straightforward first step, auctions can be implemented rapidly and realize most of the competitive benefits from moving to this type of system.

B. Process Considerations

As a threshold matter, procurement auctions are allowed under ARRA. The Broadband Technology Opportunities Program was established to provide "competitive grants."[15] While ARRA does not separately define the term "competitive grant," procurement auctions

[14] An adjustment factor would reward bidders for providing higher speed service to unserved population. For example, 1 mbps service could have a factor of 1, 10 mbps a factor of 1.5, 50 mbps, a factor of 2 and 100 mbps, a factor of 3.

[15] ARRA, Sec. 6001(g).

are simply a methodology for implementing a competitive grant program, and in this respect should be seen as the fairest and most transparent way of doing so.[16]

The framework around which an effective procurement auction can be built is simple, and immediately suggests where substantial improvements over traditional grant review or other types of procurement auction can be made.

Indication of Intent and Prescreening. In order to avoid an extended post-bidding process of weeding out and correcting frivolous bidding and overbidding, a procurement auction process must include a pre-bid indication of intent from prospective bidders and a simple prescreening process. Prescreening could be as simple as a statement committing to meet all requirements of ARRA and the procurement auction rules, coupled with a showing that the bidder can (1) meet ARRA's 20% contribution requirement and (2) pay debts up to the subsidies it receive.[17]

Substantive Preconditions. In order to limit the considerations for award as much as possible, everything extraneous to price should be made a precondition to bid – that is, any bid will assume the preconditions and any cost of compliance to be included in the bid. Doing so will increase transparency and limit the subjectivity of the final decision-making process. For example, in implementing the open access requirement, NTIA should set its rule and require bidders to meet it – bids that do not comply with the rule will be rejected. Allowing bidders to opt out of specific substantive requirements would invite gaming and undermine the objectivity of the procurement auction, removing the rationale for using an auction in the first place. Thus, NTIA should establish specific requirements for how it wants bidders to meet the substantive requirements set forth in Section 6001(e) through (h) of ARRA. Moreover, bids that fail to include clear metrics and reporting intervals consistent with these requirements should be rejected.

Combinatorial Bids and Trading. Just as ARRA requires that competitive grants be technologically neutral, the size and scope of bidders has also been left open. Indeed, ARRA appears to encourage a broad range of types and sizes of bidders. This range reflects an underlying emphasis in ARRA's broadband sections on flexibility and creativity – letting the market figure out the best way of allocating funds and expanding broadband. Rules for procurement auctions should further the goal of flexibility by making clear that bidders may combine to serve specific areas, or combine areas, as their bids may specify. Furthermore, subject to full compliance with implementing rules, NTIA should allow rights to receive the subsidy, once won, to be freely traded. Winners should be allowed to subcontract or transfer their obligation to another entity that would have otherwise been qualified to bid in the original auction. A precondition for a workable trading system, however, is that there are clear and enforced benchmarks and buildout expectations.

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[16] For a regulation to survive a challenge under the Administrative Procedure Act, a court must conclude that the regulation was not "arbitrary and capricious" or an "abuse of discretion." Given the benefits of using procurement auctions to distribute competitive grants, and ARRA's clear emphasis on speedy distribution of grants, an agency deciding to distribute funds under ARRA that opted for a less efficient and less transparent method would likely be required to explain what other factors made its decision reasonable.

[17] In order to avoid tipping their hands too early, a series of ranges of subsidies can be established, with the rules specifying that combined bids would be assumed to be able to meet the total of the combined ranges.

Provided that the underlying build out and other performance requirements are met, creating a trading system will allow winners to consolidate or diversify their obligations in a rational and efficient manner.

Transparency of Information. To the maximum extent possible, and consistent with how other auctions such as spectrum auctions have been conducted, information about the winning bidder or bidders, the amounts bid, and performance assurances must be made public and easily accessible online. It has already been established that transparency of information in a procurement auction does not violate any confidentiality of bidders that might otherwise be protected under the Federal Procurement Regulations. [18] Accordingly, NTIA should make this explicit in its implementing regulations, and explain that transparency of the process is essential not only to ensure fairness of the auction itself but also to aid in compliance.

C. Compliance and Accountability

Any subsidy or procurement plan—auction or otherwise—must include a strong mechanism for determining that firms fulfill their obligations. Performance and related assurances, such as performance bonds and other mechanisms apply to any grant program and are not unique to procurement auctions. No matter what mechanism NTIA might choose to allocate competitive grants, it will still have to address compliance and auditing. To some extent, simple prescreening of bidders will address compliance issues by ensuring that only serious bidders are engaging in the process. However, NTIA must also apply traditional performance assurance mechanisms, which are briefly discussed here.

It may be possible to require winning firms to put money in escrow that will be returned to them once they can certify that they have met their obligations (or returned in tranches as they show progress towards the goal). Forfeiture bonds are another approach. The auction design itself may be an important factor in determining whether post-auction obligations are met.

Winning bidders must make good on their bids. Holding them accountable and making sure that the subsidy actually created new economic activity requires two conditions to be true.

First, the firm must undertake the promised investment within a specified period of time. The firm should be given part of the subsidy immediately so that it can begin construction and receive the remainder in increments related to the number of households to which it has provided access. Firms that do not meet the promises made in their bids should be penalized to ensure that they have sufficient incentive to meet their obligations.

Second, the investment must not have occurred without the subsidy. Whether the investment is inframarginal is very difficult to know and it may not be possible to determine the answer conclusively for any given firm. Nevertheless, evaluating the outcome may make it possible to discern the amount of new investment created.

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[18] *Matter of: MTB Group, Inc.*, 2005 WL 433615, 2005 U.S. Comp. Gen. LEXIS 34 (2006)

IV. NTIA/RUS Should Use Procurement Auctions to Allocate a At Least A Portion of the First Wave of Broadband Stimulus Funding and Expand the Program if Successful

We realize that using competitive auctions for disbursing subsidy grants may be viewed as a change in process and that there may be some risk. As such, if auctions are not used for the entire subsidy process, we think that at least some real world analysis should take place to see how auctions perform compared to the traditional process rather than rejecting auctions completely. This section describes how such an incremental approach to using auctions could be implemented in the grant system.

As NTIA/RUS have indicated, the stimulus awards are likely to be awarded over time. We believe that that NTIA/RUS would be wise to disburse broadband grants in successive waves or rounds, so that it can improve its disbursal mechanisms iteratively throughout the lifecycle of the program. Within this context, we recommend that NTIA/RUS designate one or more geographical regions in which the first wave of funds is distributed exclusively through a procurement auction process.

This approach sets up a natural experiment allowing comparison of procurement auctions to the traditional approach. If the experiment is successful, the procurement auction mechanism can be expanded in scope to encompass other regions and stimulus dollars (potentially all remaining stimulus funds). Regardless of what mechanism is ultimately used, the lessons from the procurement auction pilot will help NTIA/RUS to learn and adapt its award mechanisms.

A procurement auction can be implemented quickly. While there are many options for designing the auction system, that fact should not serve as an argument against auctions: auctions can be implemented rapidly. In fact, auctions may take a little more time to design upfront than a generic submission system, but the investment upfront is likely to speed the overall process because it will make selection much more rapid and less arbitrary (and hence less subject to *ex post* litigation). Other countries have proposed and implemented procurement auctions for universal service rapidly and successfully.[19]

One way to use auctions for a portion of the first wave of stimulus grants would be to divide the country into large geographical regions. The "Regional Economic Area Grouping" (REAG) used by the FCC in spectrum auctions is one possible scheme to consider. In this scheme, the continental United States is divided into six regions, each containing roughly 50 million citizens and encompassing both rural and urban areas. An alternative would be to designate similarly-sized regions as aggregations of states. Whatever scheme is used, it is important that the regions are roughly similar in terms of population size and urban/rural mix.

[19] *See* Wallsten, Scott, "Reverse Auctions and Universal Telecommunications Service: Lessons from Global Experience" Federal Communications Law Journal. http://www.law.indiana.edu/fclj/pubs/v61/no2/9-WALLSTENFINAL.pdf

Then, in the first wave of stimulus disbursal, regions consisting of one-third of the U.S. population (roughly 100 million citizens) would be served through procurement auction of stimulus funds. The remaining two-thirds would be served by a conventional grant review process. A timeline would be established requiring that the first wave of funds—whether by procurement auction or by traditional grant review—shall be completed within six months. The amount of funding allocated to the first wave should reflect a practical assessment of what is feasible to disburse using the traditional process in a six-month timeframe. At the end of the period, the NTIA/RUS should take one month to compare results of the two programs and to assess the results, before making a determination whether to use procurement auctions in subsequent rounds.

Should NTIA/RUS decide to continue or expand the use of procurement auctions, the mechanism can be tweaked to incorporate lessons from the first wave. However, even if NTIA/RUS decides to proceed through entirely conventional means, the procurement auction will undoubtedly provide important lessons (e.g., bidder receptiveness to quantitative targets) that will inform refinements to the conventional approach.

V. Conclusion

A traditional grant application review process may prove to be inadequate to the herculean task of distributing broadband stimulus grants. It is likely to be slow, cumbersome, and will result in a suboptimal allocation of resources. By contrast, competitive bidding, through the use of procurement auctions, can allocate the funds quickly and efficiently. While we advocate using procurement auctions to distribute all of the broadband stimulus money, allocating even a portion of the funds using procurement auctions would be useful as an experiment. At a minimum, the broadband stimulus funds present a golden opportunity to implement rigorous evaluation techniques, which will generate knowledge that can be applied to other current and future programs. To that end it is important to include procurement auctions as one approach to be tested.

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THE BROADBAND AVAILABILITY GAP

OBI TECHNICAL PAPER NO. 1

APPENDIX C

Omnibus Broadband Initiative, The Broadband Availability Gap

TABLE OF CONTENTS

LIST OF EXHIBITS

LIST OF ASSUMPTIONS

This table provides important information about the different assumptions used in the creation of charts throughout this document. The assumptions implicit in each chart are appropriate for the context in which the chart appears. However, it may be the case that assumptions vary between similar charts, leading to what appear to be different results. This table synthesizes the different assumptions to allow the reader to interpret and compare charts in this document.

			Key assumptions	
Chart	Description	Technology	4G Areas	Non-4G areas
1-A	Base-case Broadband Availability Gap Profitable counties are excluded.	12,000-foot DSL	Assumes one competitor.	Assumes no competitors.
		Fixed Wireless	Assumes no competitors. Applies a 73.13% cost allocation to the fixed network. Recognizes only Fixed revenue as incremental.	Assumes no competitors. Recognizes Fixed and Mobile revenue as incremental.
1-B	Breakout of Ongoing Costs by Category Profitable counties are excluded.	12,000-foot DSL	Assumes one competitor.	Assumes no competitors.
		Fixed Wireless	Assumes no competitors. Applies a 73.13% cost allocation to the fixed network. Recognizes only Fixed revenue as incremental.	Assumes no competitors. Recognizes Fixed and Mobile revenue as incremental.
1-C	Gap by Census Blocks Ordered by Population density The second lowest cost technology is determined at the county level and assigned to the census blocks. All unserved census blocks then are sorted into centiles by their gap.	12,000-foot DSL	Assumes one competitor.	Assumes no competitors.
		Fixed Wireless	Assumes no competitors. Applies a 73.13% cost allocation to the fixed network. Recognizes only Fixed revenue as incremental.	Assumes no competitors. Recognizes Fixed and Mobile revenue as incremental.
1-D	Broadband Investment Gap per County	12,000-foot DSL	Assumes one competitor.	Assumes no competitors.
		Fixed Wireless	Assumes no competitors. Applies a 73.13% cost allocation to the fixed network. Recognizes only Fixed revenue as incremental.	Assumes no competitors. Recognizes Fixed and Mobile revenue as incremental.
1-E	Broadband Investment Gap per Housing Unit in Each County	12,000-foot DSL	Assumes one competitor.	Assumes no competitors.
		Fixed Wireless	Assumes no competitors. Applies a 73.13% cost allocation to the fixed network. Recognizes only Fixed revenue as incremental.	Assumes no competitors. Recognizes Fixed and Mobile revenue as incremental.
1-G	Broadband Investment Gap, by County Profitable counties are excluded.	12,000-foot DSL	Assumes one competitor.	Assumes no competitors.
		Fixed Wireless	Assumes no competitors. Applies a 73.13% cost allocation to the fixed network. Recognizes only Fixed revenue as incremental.	Assumes no competitors. Recognizes Fixed and Mobile revenue as incremental.
1-H	Ongoing Support for Each Housing Unit per Month	12,000-foot DSL	Assumes one competitor.	Assumes no competitors.
		Fixed Wireless	Assumes no competitors. Applies a 73.13% cost allocation to the fixed network. Recognizes only Fixed revenue as incremental.	Assumes no competitors. Recognizes Fixed and Mobile revenue as incremental.
1-I	Investment Gap per Housing Unit by Lowest-Cost Technology for Each County	12,000-foot DSL	Assumes one competitor.	Assumes no competitors.
		Fixed Wireless	Assumes no competitors. Applies a 73.13% cost allocation to the fixed network. Recognizes only Fixed revenue as incremental.	Assumes no competitors. Recognizes Fixed and Mobile revenue as incremental.

Chart	Description	Technology	Key assumptions	
			4G Areas	Non-4G areas
1-J	Lowest Cost Technology All unserved areas are included.	12,000-foot DSL	Assumes one competitor.	Assumes no competitors.
		Fixed Wireless	Assumes no competitors. Applies a 73.13% cost allocation to the fixed network. Recognizes only Fixed revenue as incremental.	Assumes no competitors. Recognizes Fixed and Mobile revenue as incremental.
3-A	Impact of Discount Rate on Investment Gap Profitable counties are excluded.	12,000-foot DSL	Assumes one competitor.	Assumes no competitors.
		Fixed Wireless	Assumes no competitors. Applies a 73.13% cost allocation to the fixed network. Recognizes only Fixed revenue as incremental.	Assumes no competitors. Recognizes Fixed and Mobile revenue as incremental.
3-D	Gap for Funding One Wired and One Wireless Network Profitable counties for each technology are excluded.	12,000-foot DSL	Assumes one competitor.	Assumes no competitors.
		Fixed Wireless	Assumes no competitors. Applies a 73.13% cost allocation to the fixed network. Recognizes only Fixed revenue as incremental.	Assumes no competitors. Recognizes Fixed and Mobile revenue as incremental.
3-E	The Cost of Funding Two Wired Networks Profitable counties for each technology are excluded.	12,000-foot DSL	Assumes one competitor.	Assumes one competitor.
		FTTP	Assumes one competitor.	Assumes one competitor.
3-G	Quantifying the Impact of Competition: Investment Gap by Number of Providers Profitable counties are excluded.	12,000-foot DSL	Assumes 0-3 competitors as indicated by label.	Assumes 0-3 competitors as indicated by label.
		Fixed Wireless	Assumes 0-3 competitors as indicated by label. Applies a 73.13% cost allocation to the fixed network. Recognizes only Fixed revenue as incremental.	Assumes 0-3 competitors as indicated by label. Recognizes only Fixed revenue as incremental.
3-H	Broadband Investment Gap by Percent of Unserved Housing Units The second-lowest-cost technology is determined at the county level and assigned to the census blocks. All unserved census blocks then are sorted into centiles by their gap.	12,000-foot DSL	Assumes one competitor.	Assumes no competitors.
		Fixed Wireless	Assumes no competitors. Applies a 73.13% cost allocation to the fixed network. Recognizes only Fixed revenue as incremental.	Assumes no competitors. Recognizes Fixed and Mobile revenue as incremental.
3-I	Total Investment Cost for Various Upgrade Paths	12,000-foot DSL	Assumes one competitor.	Assumes no competitors.
		Fixed Wireless	Assumes no competitors. Applies a 73.13% cost allocation to the fixed network.	Assumes no competitors.
		5,000-foot DSL	Assumes one competitor.	Assumes no competitors.
		3,000-foot DSL	Assumes one competitor.	Assumes no competitors.
		FTTP	Assumes one competitor.	Assumes no competitors.
3-M	Dependence of the Broadband Investment Gap on Speed of Broadband Considered Profitable counties are excluded.	15,000-foot DSL	Assumes one competitor.	Assumes no competitors.
		12,000-foot DSL	Assumes one competitor.	Assumes no competitors.
		Fixed Wireless	Assumes no competitors. Applies a 73.13% cost allocation to the fixed network. Recognizes only Fixed revenue as incremental.	Assumes no competitors. Recognizes Fixed and Mobile revenue as incremental.
		5,000-foot DSL	Assumes one competitor.	Assumes no competitors.
		3,000-foot DSL	Assumes one competitor.	Assumes no competitors.
		FTTP	Assumes one competitor.	Assumes no competitors.
		HFC	Assumes one competitor.	Assumes no competitors.

Chart	Description	Technology	Key assumptions	
			4G Areas	Non-4G areas
3-U	Sensitivity of Gap to Take Rate Profitable counties are excluded.	12,000-foot DSL	Assumes one competitor.	Assumes no competitors.
		Fixed Wireless	Assumes no competitors. Applies a 73.13% cost allocation to the fixed network. Recognizes only Fixed revenue as incremental.	Assumes no competitors. Recognizes Fixed and Mobile revenue as incremental.
3-W	ARPU Sensitivity Profitable counties are excluded.	12,000-foot DSL	Assumes one competitor.	Assumes no competitors
		Fixed Wireless	Assumes no competitors. Applies a 73.13% cost allocation to the fixed network. Recognizes only Fixed revenue as incremental.	Assumes no competitors. Recognizes Fixed and Mobile revenue as incremental.
3-Z	Sensitivity of Build-Out Cost and Investment Gap to Terrain Classification Parameters Profitable counties are excluded.	Fixed Wireless	Assumes no competitors. Applies a 73.13% cost allocation to the fixed network. Recognizes only Fixed revenue as incremental.	Assumes no competitors. Recognizes Fixed and Mobile revenue as incremental.
4-C	Present Value of Total Costs for All Technologies in Unserved Areas The second lowest cost technology is determined at the county level and assigned to the census blocks. All unserved census blocks then are sorted into centiles by their gap.	12,000-foot DSL	Assumes no competitors.	Assumes no competitors.
		Fixed Wireless	Assumes no competitors. Applies a 73.13% cost allocation to the fixed network.	Assumes no competitors.
		5,000-foot DSL	Assumes no competitors.	Assumes no competitors.
		3,000-foot DSL	Assumes no competitors.	Assumes no competitors.
		FTTP	Assumes no competitors.	Assumes no competitors.
		Cable	Assumes no competitors.	Assumes no competitors.
4-W	Investment Gap for Wireless networks Profitable counties are excluded.	Fixed Wireless	Assumes no competitors. Applies a 73.13% cost allocation to the fixed network. Recognizes only Fixed revenue as incremental.	Assumes no competitors. Recognizes Fixed and Mobile revenue as incremental.
4-Y	Sensitivity of Investment Gap to Terrain Classification Profitable counties are excluded.	Fixed Wireless	Assumes no competitors. Applies a 73.13% cost allocation to the fixed network. Recognizes only Fixed revenue as incremental.	Assumes no competitors. Recognizes Fixed and Mobile revenue as incremental.
4-Z	Sensitivity of Costs and Investment Gap to Subscriber Capacity Assumptions Profitable counties are excluded.	Fixed Wireless	Assumes no competitors. Applies a 73.13% cost allocation to the fixed network. Recognizes only Fixed revenue as incremental.	Assumes no competitors. Recognizes Fixed and Mobile revenue as incremental.
4-AA	Impact of Spectrum Availability on FWA Economics Considers all unserved areas for first column of data; profitable counties are excluded in the other columns.	Fixed Wireless	Assumes no competitors. Applies a 73.13% cost allocation to the fixed network. Recognizes only Fixed revenue as incremental.	Assumes no competitors. Recognizes Fixed and Mobile revenue as incremental.
4-AB	Cost Breakdown of Wireless Network Over 20 Years Considers all unserved areas (including profitable counties).	Fixed Wireless	Assumes no competitors. Applies a 73.13% cost allocation to the fixed network.	Assumes no competitors.
4-AC	Cost of Deploying a Wireless Network in Unserved Areas Considers all unserved areas (including profitable counties).	Fixed Wireless	Assumes no competitors. Applies a 73.13% cost allocation to the fixed network.	Assumes no competitors.

Chart	Description	Technology	Key assumptions	
			4G Areas	Non-4G areas
4-AD	Cost of an HFM Second Mile Backhaul Architecture	Fixed Wireless	Assumes no competitors. Applies a 73.13% cost allocation to the fixed network.	Assumes no competitors.
4-AK	Economic Breakdown of 12,000-foot DSL Profitable counties are excluded.	12,000-foot DSL	Assumes one competitor.	Assumes no competitors.
4-AP	Economics of Terrestrially Served if Most Expensive Housing Units are Served with Satellite Includes all unserved areas (including profitable counties).	12,000-foot DSL	Assumes one competitor.	Assumes no competitors.
		Fixed Wireless	Assumes no competitors. Applies a 73.13% cost allocation to the fixed network. Recognizes only Fixed revenue as incremental.	Assumes no competitors. Recognizes Fixed and Mobile revenue as incremental.
4-AV	Breakout of FTTP Gap Profitable counties are excluded.	FTTP	Assumes no competitors.	Assumes no competitors.
4-BE	Breakout of 3,000-Foot DSL Gap Profitable counties are excluded.	3,000-foot DSL	Assumes no competitors.	Assumes no competitors.
4-BF	Breakout of 5,000-Foot DSL Gap Profitable counties are excluded.	5,000-foot DSL	Assumes no competitors.	Assumes no competitors.
4-BG	Breakout of 15,000-Foot DSL Gap Profitable counties are excluded.	15,000-foot DSL	Assumes one competitor.	Assumes no competitors.

INTRODUCTION

The American Recovery and Reinvestment Act directed the Federal Communications Commission (FCC) to include, as part of the National Broadband Plan (NBP), "an analysis of the most effective and efficient mechanisms for ensuring broadband access by all people of the United States."[1] As the NBP indicated, the level of additional funding to extend broadband to those who do not have access today is $23.5 billion; more detail about the gap and results of this analysis are presented in Chapter 2. This document details the underlying analyses, assumptions and calculations that support the $23.5 billion funding gap.[2]

The question implicit in the Congressional mandate is deceptively simple: What is the minimum level of public support necessary to ensure that all Americans have access to broadband? In fact, there are multiple layers of complexity: The analysis must account for existing deployments, both to the extent that they enable current service and can be used to extend service to currently unserved areas; and it must include an analysis of the capabilities and economics of different, competing technologies that can provide service. The analysis therefore comprises two main components: The first focuses on *Availability*, or understanding the state of existing network deployments and services; the second focuses on the *Funding Shortfall*, the capabilities and economics associated with different broadband networks.[3] See Exhibit A.

The *Availability* analysis focuses on determining the state of existing deployments: who has access, and of greater concern, who lacks access to broadband consistent with the National Broadband Availability Target. In addition, this analysis must develop a key input to the Funding Shortfall analysis: data regarding the location of existing network infrastructure to facilitate determining the cost of extending service into unserved areas. Developing this detailed baseline requires a very granular geographic view of the capabilities of all the major types of broadband infrastructure as they are deployed today, and as they will likely evolve over the next three to five years without public support.

Unfortunately, there is a lack of data at the required level of granularity, both in terms of availability—which people have access to what services—and of infrastructure—which people are passed by what types of network hardware. To solve the problem, we combine several data sets for availability and infrastructure, supplementing nationwide data with the output of a large multivariate regression model. We use this regression model to predict availability by speed tier and to fill in gaps, especially last-mile gaps, in our infrastructure data. The approach to developing this baseline is described in Chapter 2.

The second major component focuses on the *Funding Shortfall* by examining the capabilities and economics of different network technologies. To facilitate this analysis, we built a robust economic model that calculates the amount of support necessary to upgrade or extend existing infrastructure to the unserved to provide service consistent with the target. The economic analysis builds on the infrastructure data—known and inferred—from the first step, calculating the cost to augment existing infrastructure to provide broadband service consistent with the target for multiple technologies.

This calculation ultimately provides the gap between likely commercial deployments and the funding needed to extend universal broadband access to the unserved. Underlying the model's construction are a number of principles that guided its design.

- **Only profitable business cases will induce incremental network investments.** Private capital will only be available to fund investments in broadband networks where it is possible to earn returns in excess of the cost of capital. In short, only profitable networks will attract the investment required. Cost, while a significant

BOX A

The Broadband Availability Gap Model

Models are one tool to analyze complex problems such as the Broadband Availability Gap. It is important to recognize, however, that models have limits. An engineering-based, multi-technology economic model of broadband deployment, like the one created as part of the National Broadband Plan (NBP) effort, requires a multitude of inputs and can be used to answer many different questions. The types of inputs range from simple point estimates, such as the cost of a piece of hardware—a Digital Subscriber Line Access Multiplexer (DSLAM) card or chassis, for example— estimates of per-product revenue, assumptions about the evolution of competitive dynamics in different market segments and the likely behavior of service providers. We form hypotheses about all of these types of inputs to calculate the Broadband Availability Gap; of necessity, some of these hypotheses are more speculative than others.

This paper describes the design and use of this model in providing input into the NBP, as well as the underlying views about the relevant technologies. Others may make different assumptions or test different hypotheses or seek to answer somewhat different questions. The model and its associated documentation provide an unprecedented level of transparency and should spur debate. The intent is for this debate to ultimately improve our understanding of the economics related to offering broadband service so that public policy can be made in a data-driven manner.